EVE: An EnVironmEnt For On-Board Processing (AIST-99-0007)

Earth Science Technology Conference

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Project Overview – The Team

- Funding from Earth Science Technology Office
  3 year effort starting January 31, 2001

- Key personnel
  - Sara Graves – PI
  - Helen Conover – Technical Lead
  - Steve Tanner – Team Lead

    Mohammad Alshayeb – User Interface
    Evans Criswell – Operations Development
    Drew McDowell – Executive Development
    Michael McEniry – Hardware Testbed/OS
    Kathryn Regner – Software Engineering

Project Overview
- EVE Requirements

- Prototype a processing framework for the on-board satellite environment.
- Provide specific capabilities within the framework
  - Data Mining
  - Classification
  - Feature Extraction
- Support research applications
  - Multi-sensor fusion
  - Intelligent sensor control
  - Real-time customized data products
- Create a laboratory testbed

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Project Overview
- Original schedule with enhancements

- Year 1:
  - Define and verify a software architecture for on-board processing
  - Build basic preliminary processing framework
  - Add initial operations – small and specialized
  - Support easy reconfiguration of operations and framework
  - Extend the architecture for branching and multiprocessing
- Year 2:
  - Port to real-time embedded environment in order to validate the framework and its operations
  - Develop a processing plan syntax
  - Develop a Web-based user interface for plan development and test
  - Incorporate operations from other sources
- Year 3:
  - Add data input components based upon known or expected sensors
  - Add other operations
  - Make significant user interface improvements
  - Port to Win-CE platforms for sensor web prototyping
  - Verify in a flight of opportunity if possible (OMNI, UAV, Flight Linux, Ball Aerospace, TRW, etc.)

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Porting the On-board System to Win-CE

Rationale

- Supports an expanded base of platforms
  - Including several UAV/UGV systems and many ground-based sensor platforms
  - Interest from DoD and industry for ground-based applications including security, intelligence gathering, etc

Tasks

- Porting the RTLinux components to Win-CE
- Incorporating communications standards
  - (e.g. Open Grid Services Infrastructure, OGSI)
- Developing a process to enable the use of all current operations on both RTLinux and Win-CE platforms
- Developing new operations specific to the platforms
- Incorporating new sensor hardware into the testbed

Year 3 Activities

- Provide Processing Plan Syntax for use by others to develop new operations and on-board plans
- Provide access to the prototype web based user interface and the EVE system framework
- Implement and add new operations to the system
- Incorporate additional operations from other sources
- Increase data input components based upon known and expected sensors
- Provide event triggering across multiple platforms
- Support the Win-CE environment

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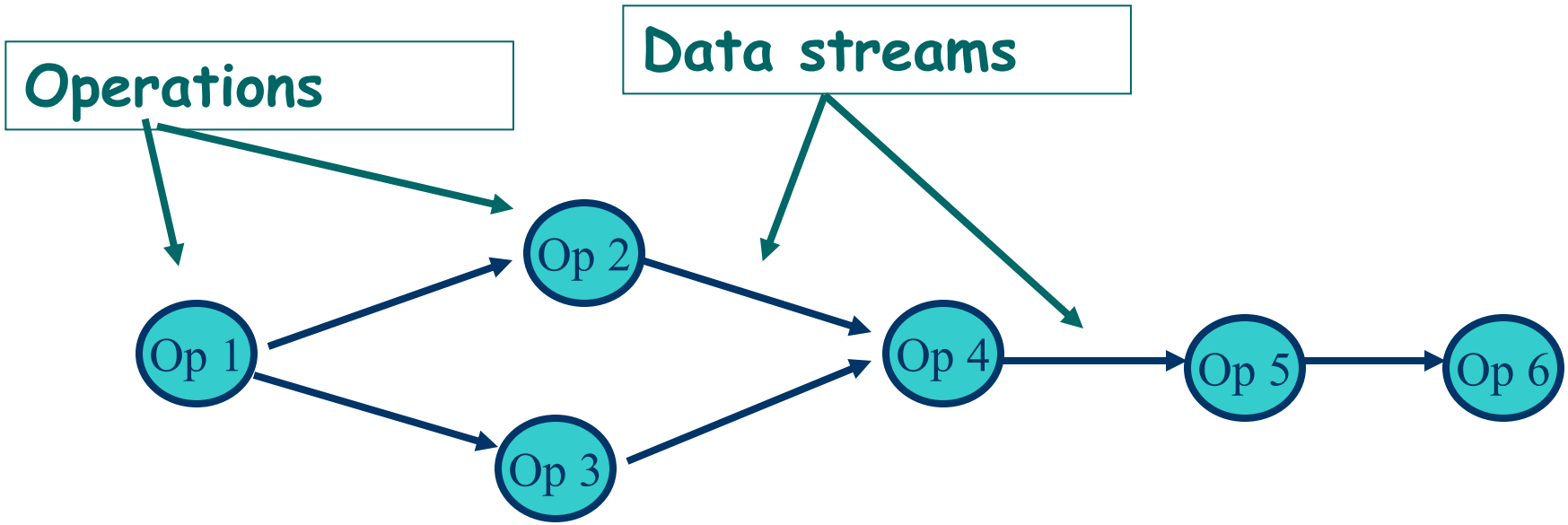
Design Overview: What is a Plan?

A Processing Plan:
Specifies a set of operations and the data stream connections between them



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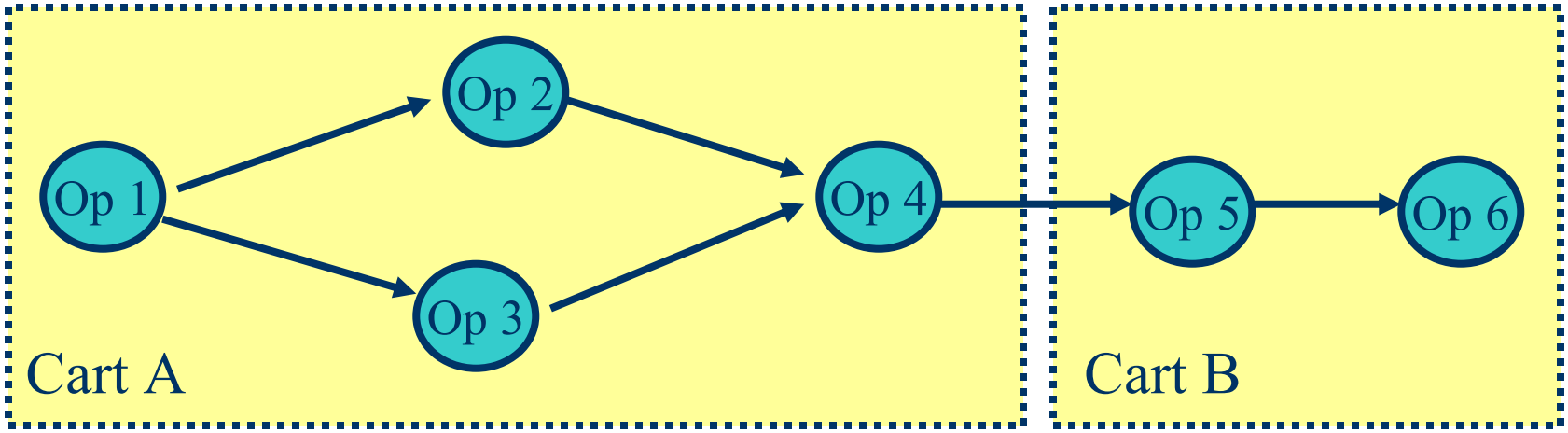
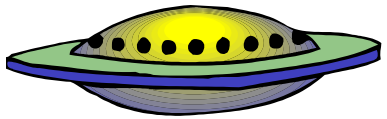
Design Overview: What is a Cart?

Holds the operations of a plan that will be executed as a single real-time unit

Has knowledge of resource limitations on a platform and resource usage of operations



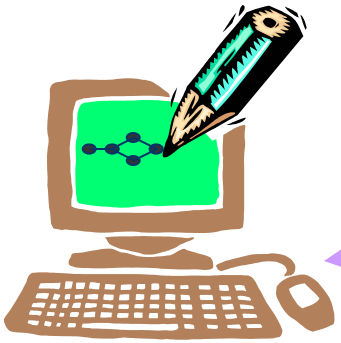
EVE Functional Flow: Getting a plan on-board



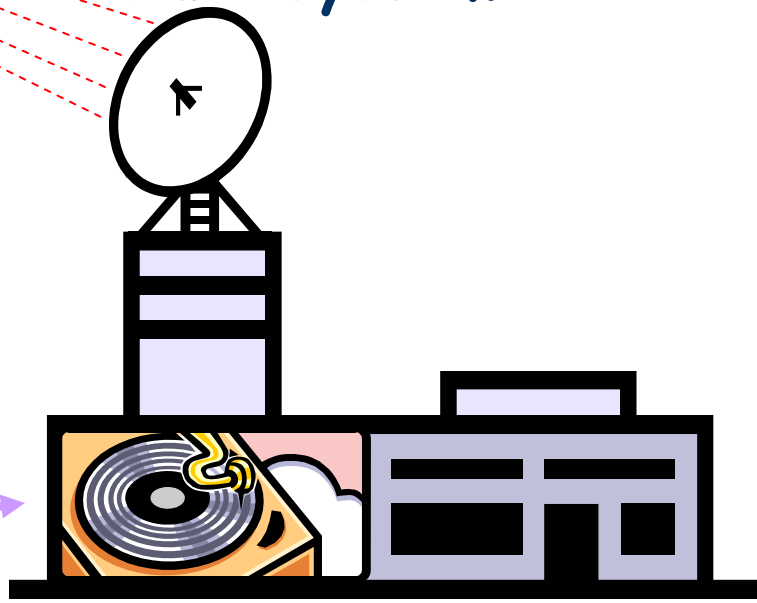
EVE On-board System

2. The ground station sends the plan on to the appropriate on-board system

3. The on-board system creates the carts for execution



Editor



Ground Station with SMAC

1. The user edits a processing plan and sends an XML description to the ground station

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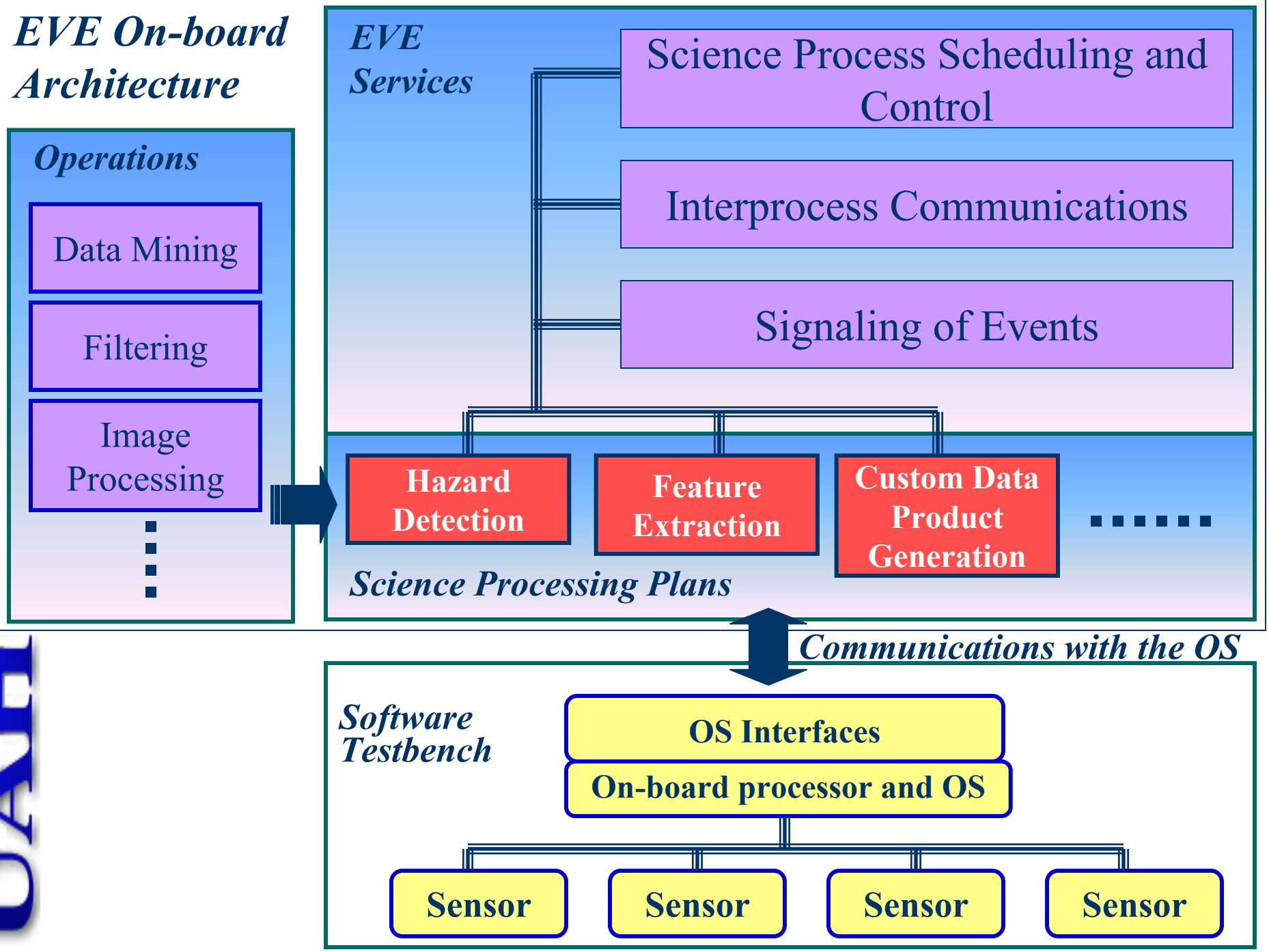
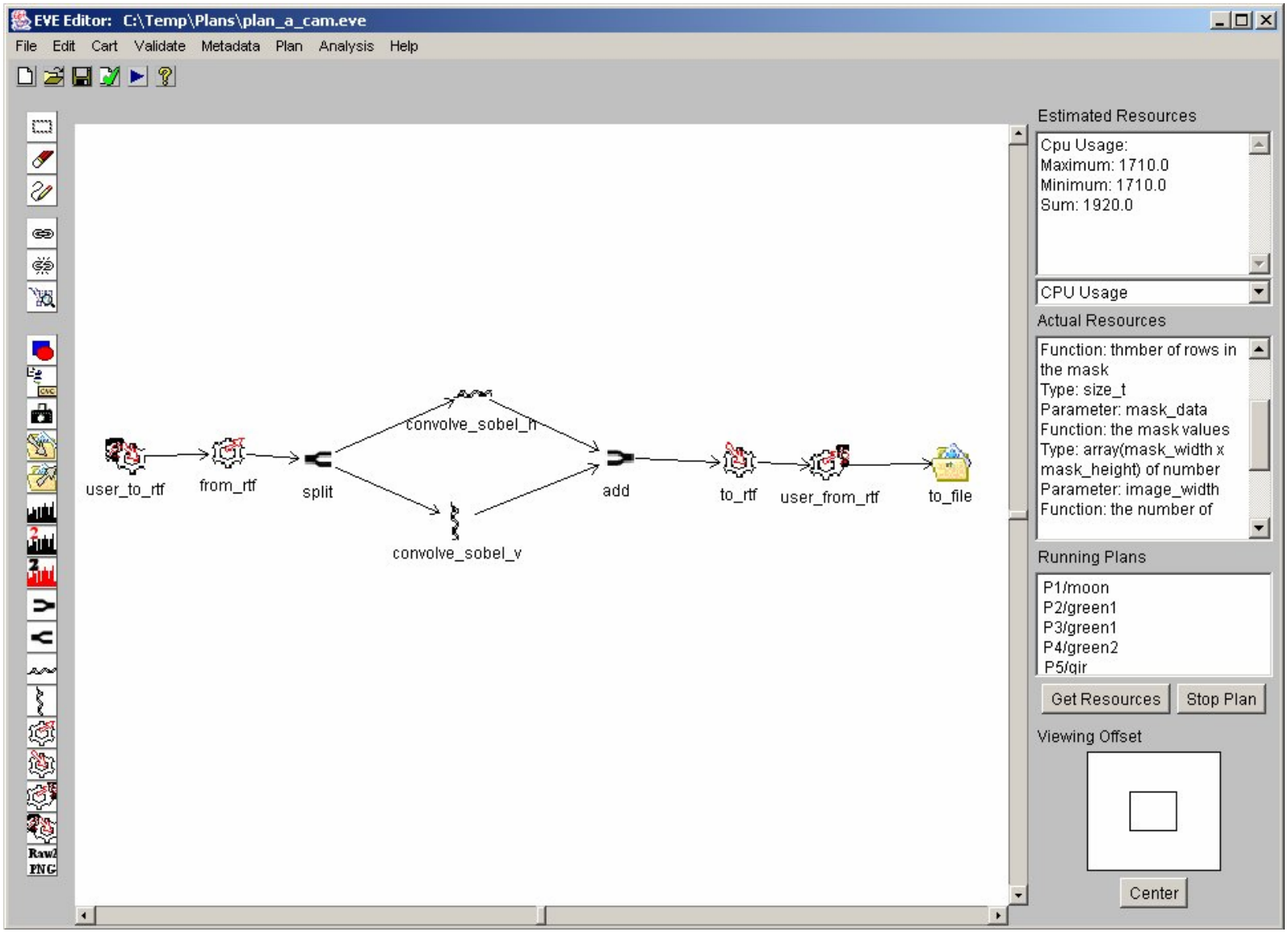
EVE On-board Architecture



Editor Features



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Close up of Major Editor Features

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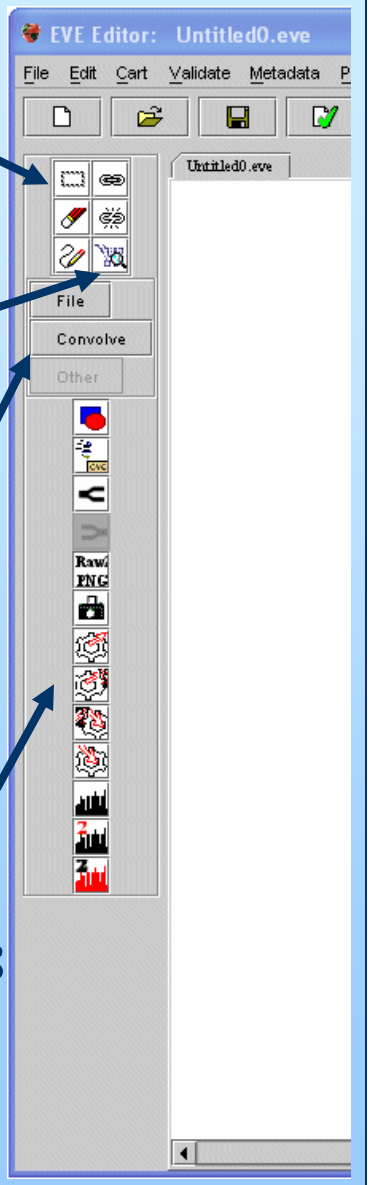
Editing tools

Cart building tools

Operation Categories

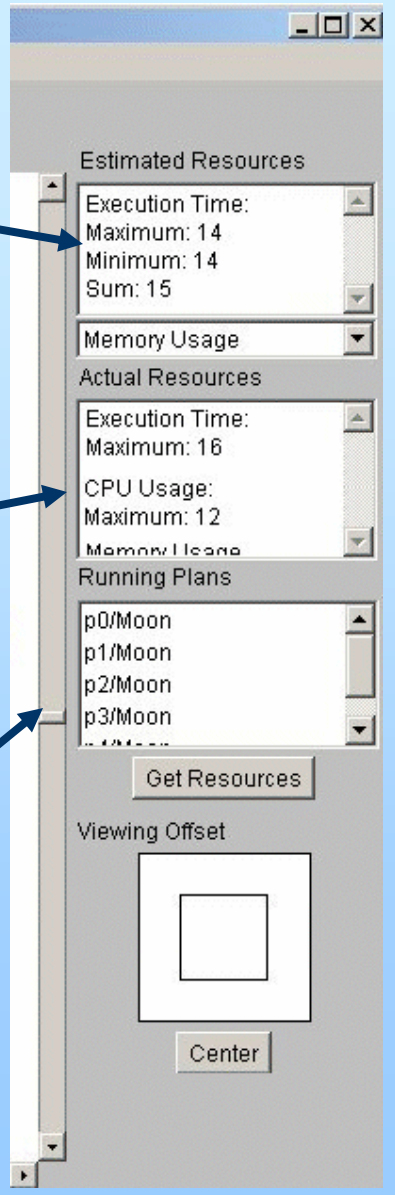
Specific Operations



Estimated Resource Information

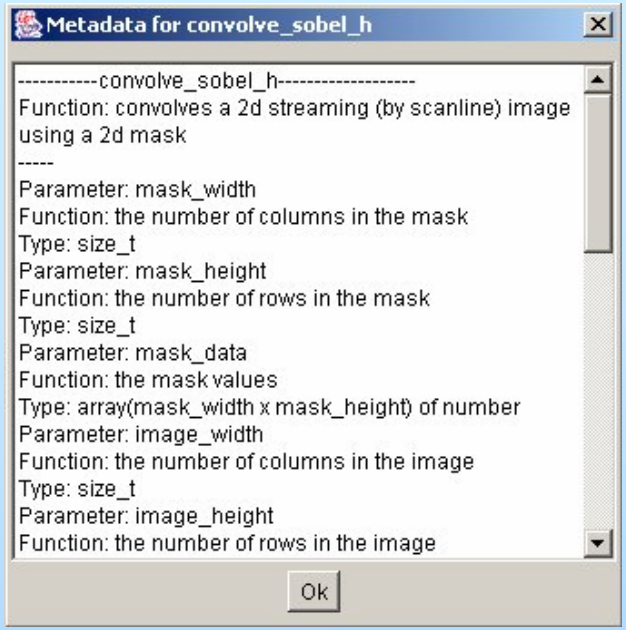
Actual On-board Resource Usage

Actual On-board Cart Information



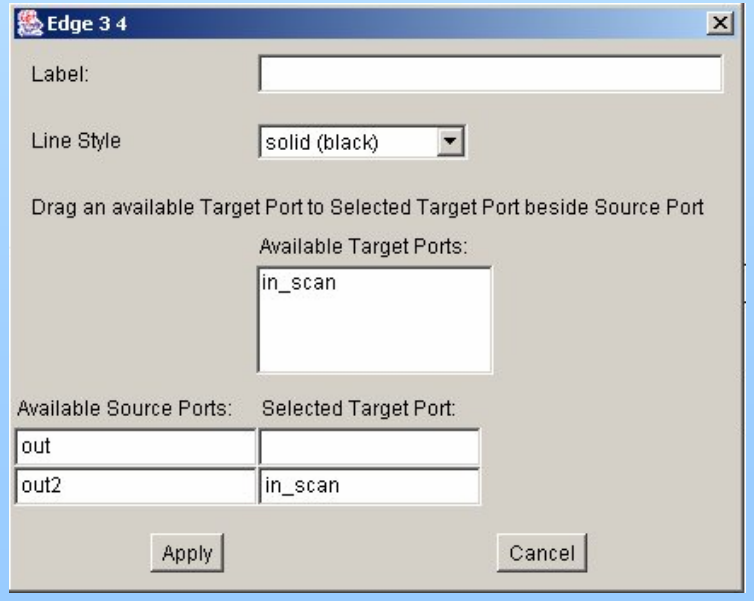
Close up of Major Editor Features (cont)

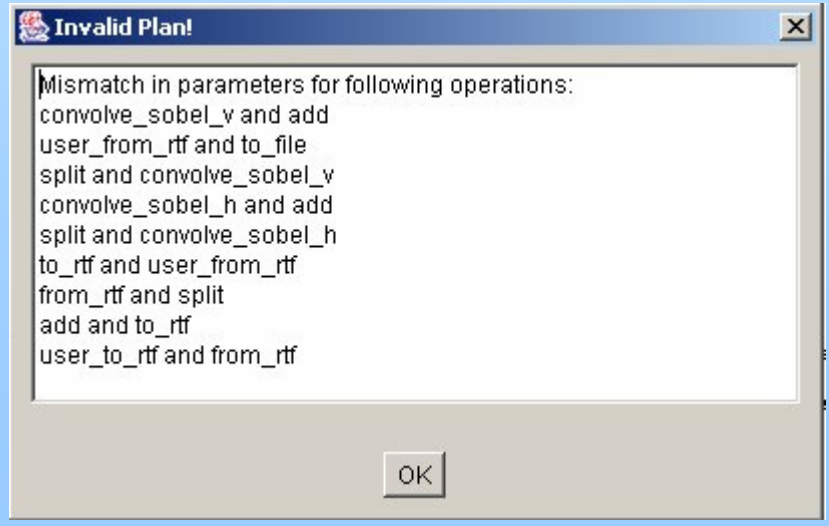
Operation Metadata Access



Operation Linkage Tools

Plan Validation Tools



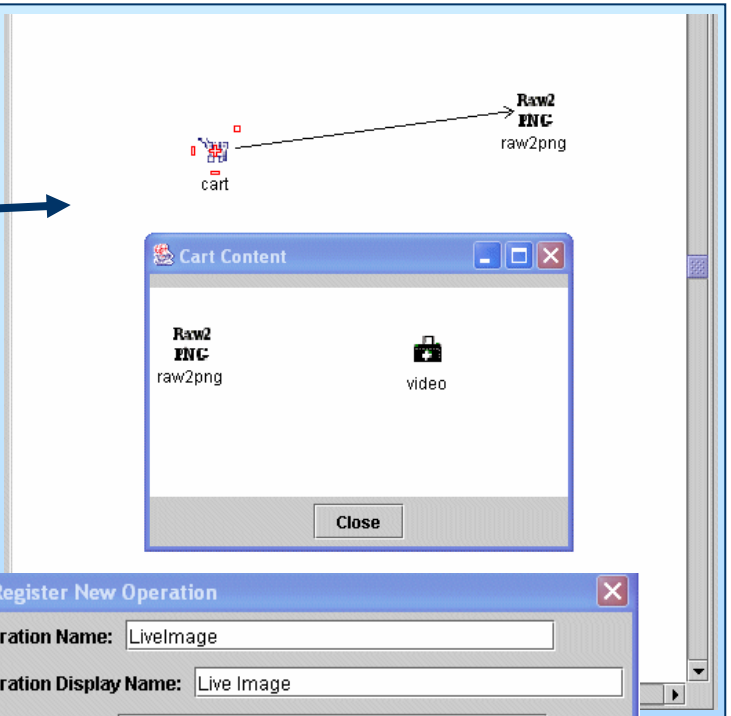


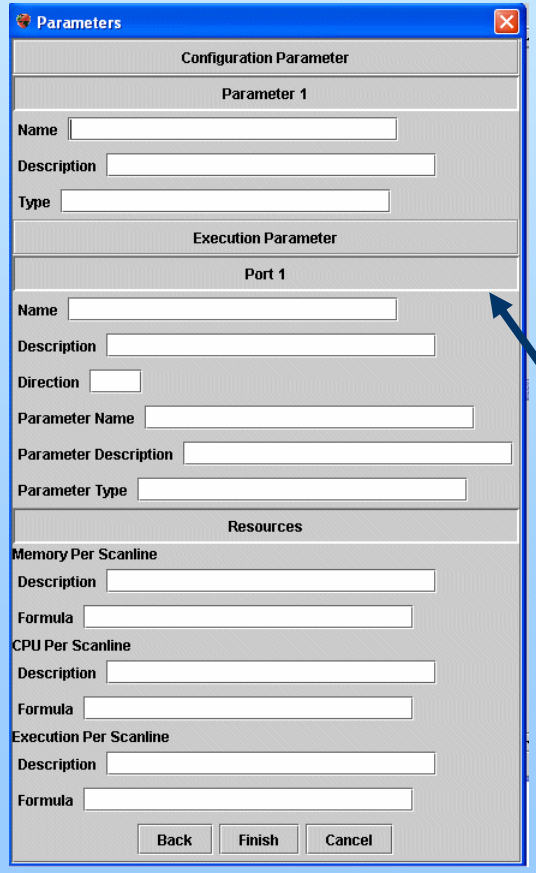
Editor Enhancements: Usability

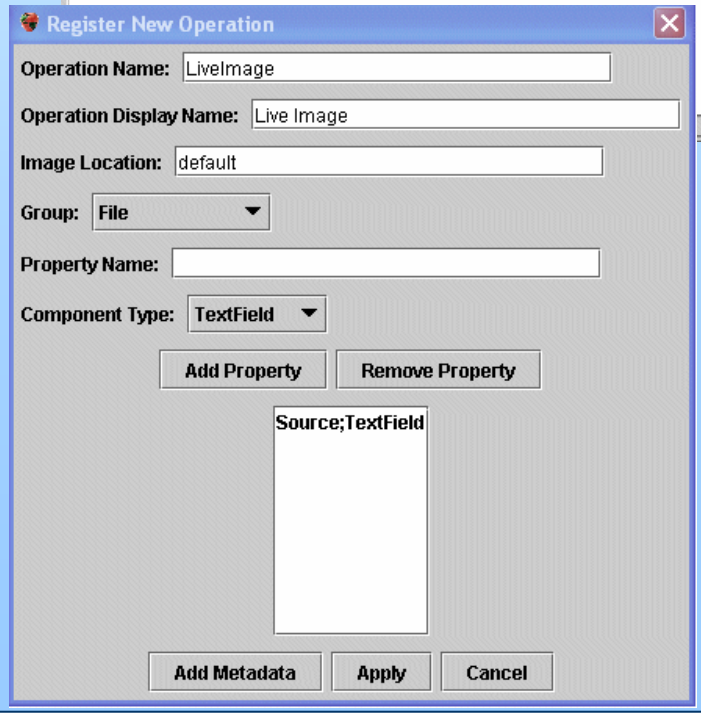
Improved Cart Editing Tools

User Registration of New Operations

User Editing of Metadata







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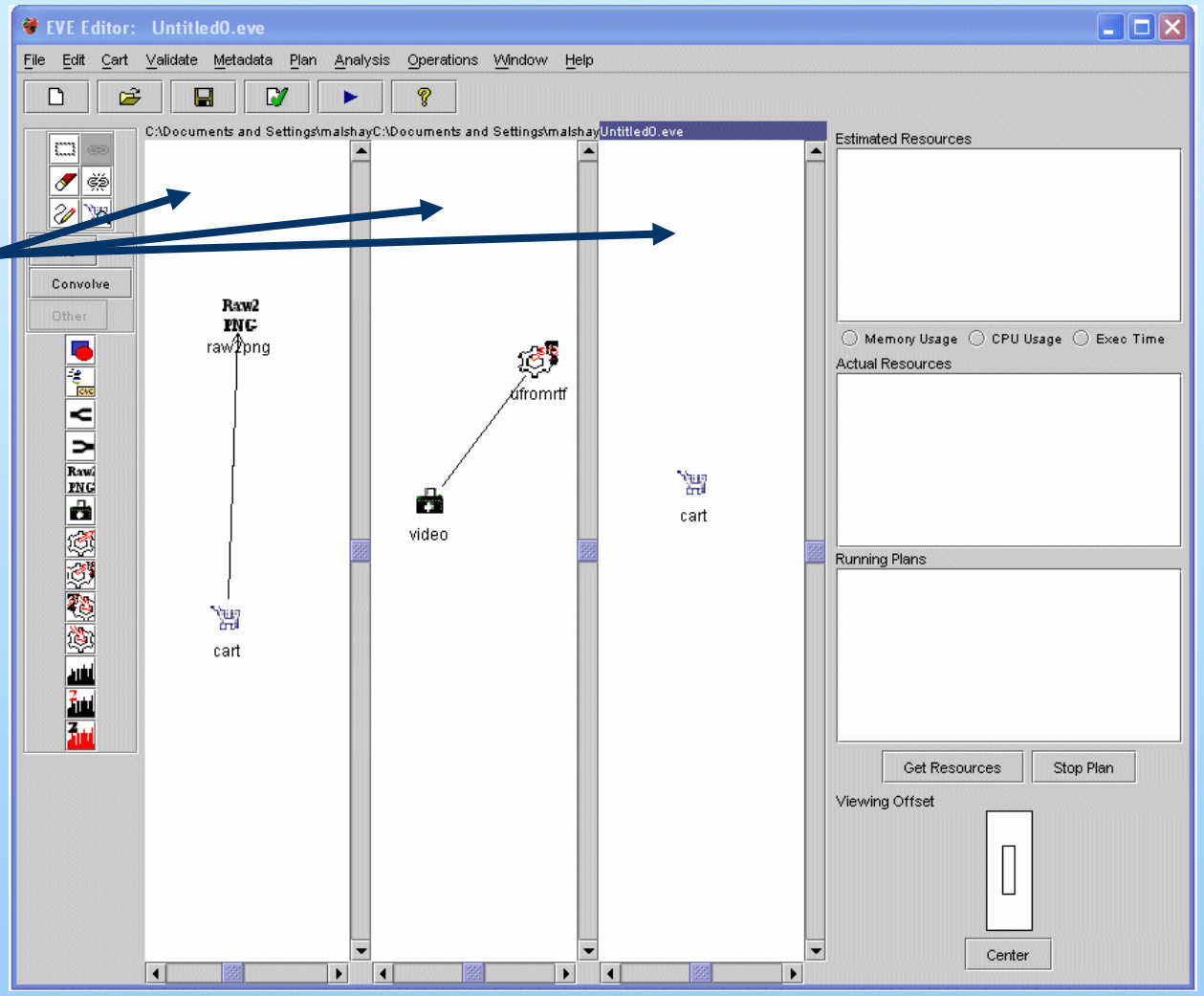
Editor/Ground-station/On-board system Enhancements: Multiple Plans on Multiple Platforms

Each panel represents a separate plan

Each plan has its own set of carts and operations



Each plan has its own target platform, schedule, event notification, etc.

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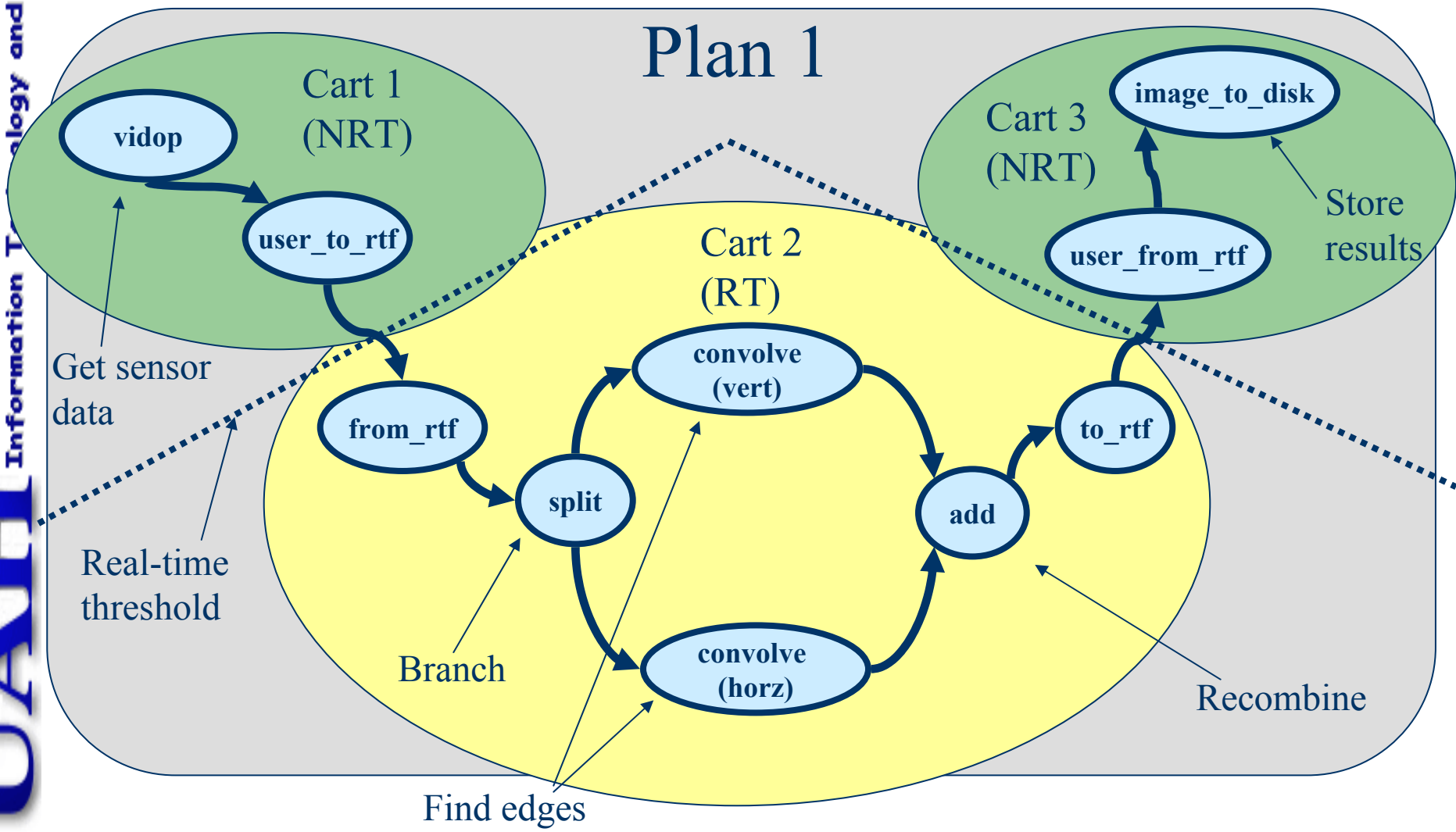
Processing Plan Example: Real-Time Edge Detection

- Branching and recombining
- Multiple carts, real-time and non-real-time



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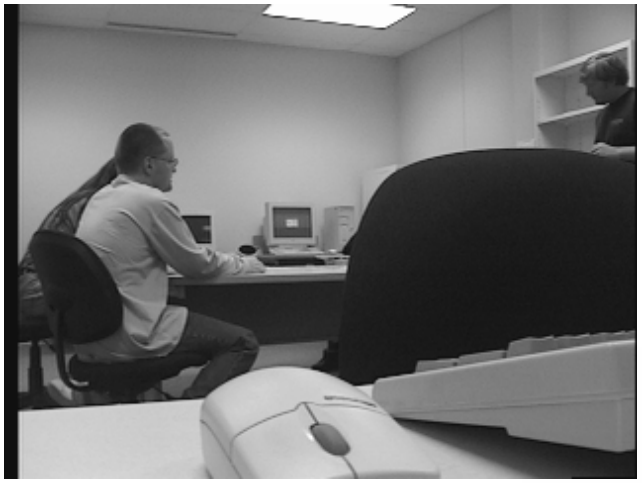
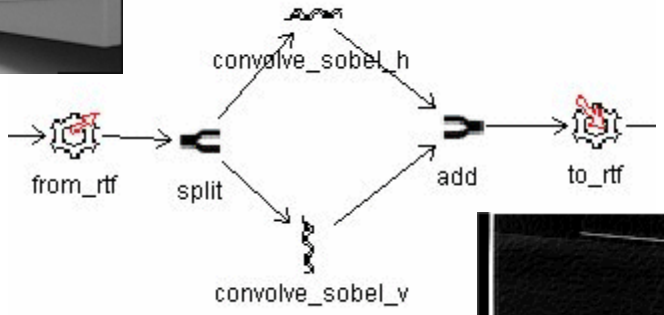
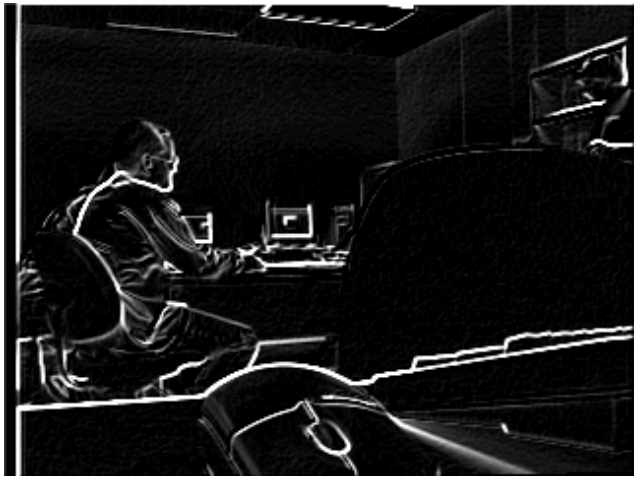
Processing Plan Example (con't): Real-Time Edge Detection



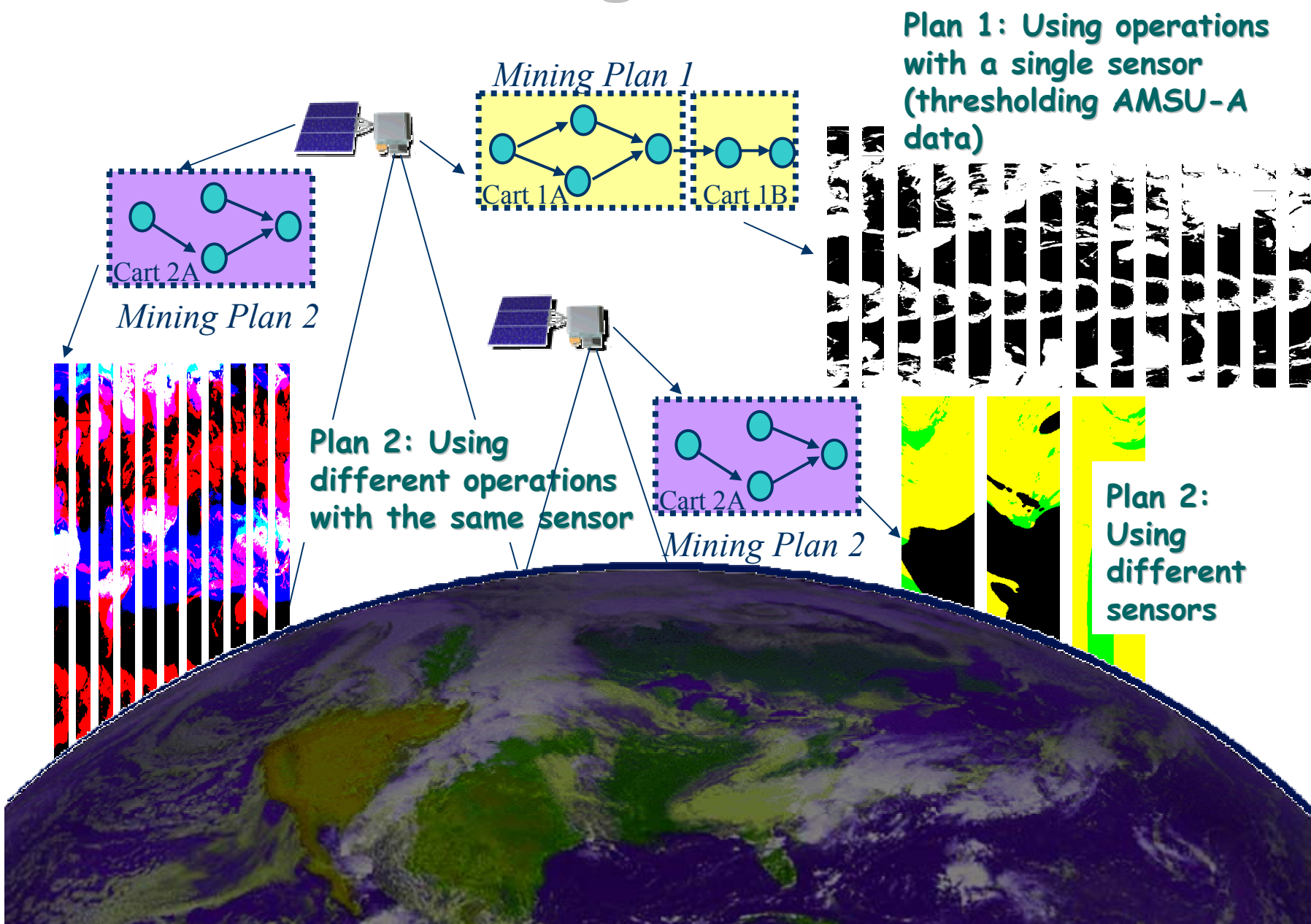
- Significant speed improvement
  - 5+ images per second
- Can be used with many sensors



- Edge Detection output is used by other processes
- Can be the basis for further feature extraction plans



On-board mining with EVE



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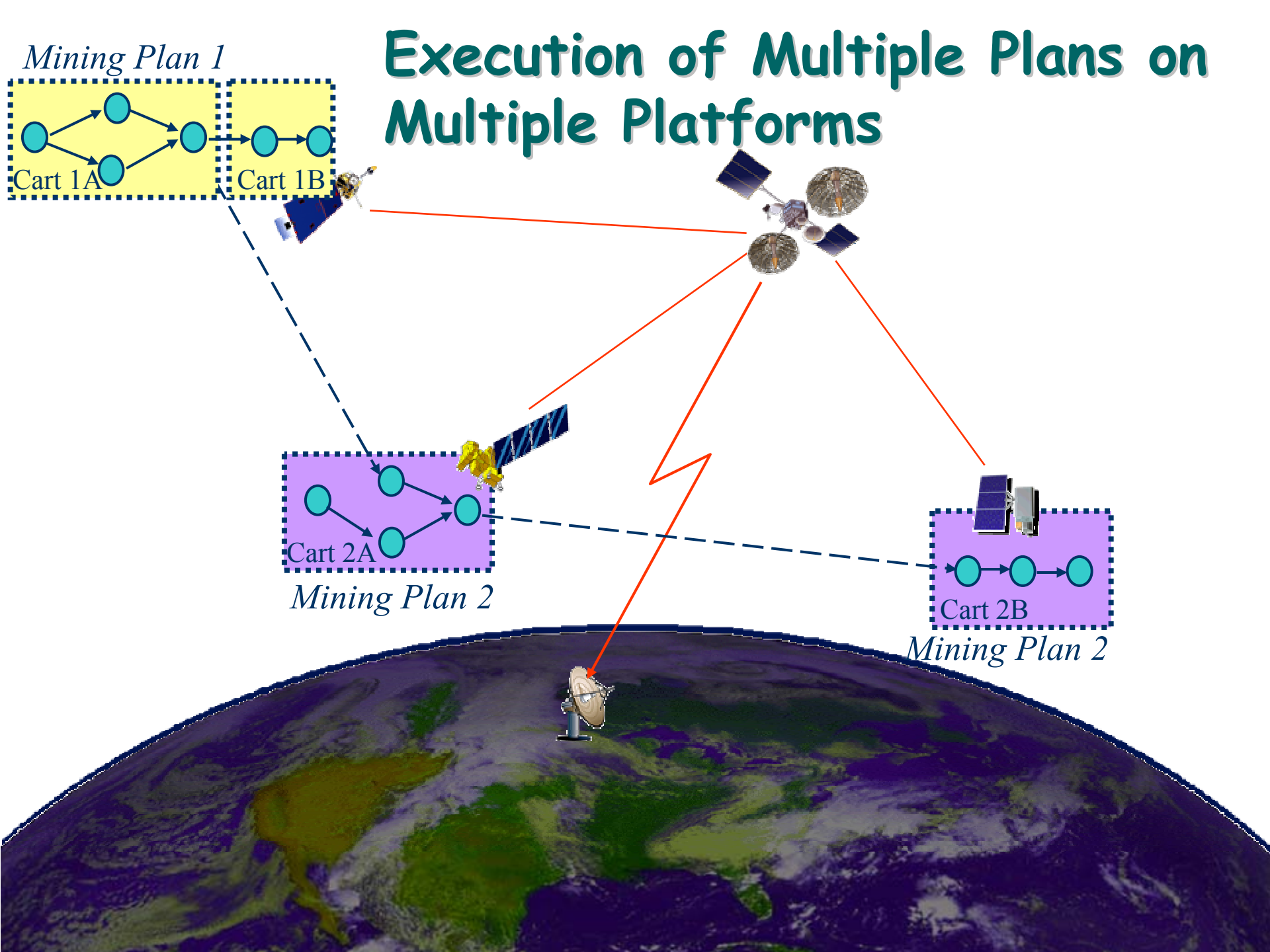
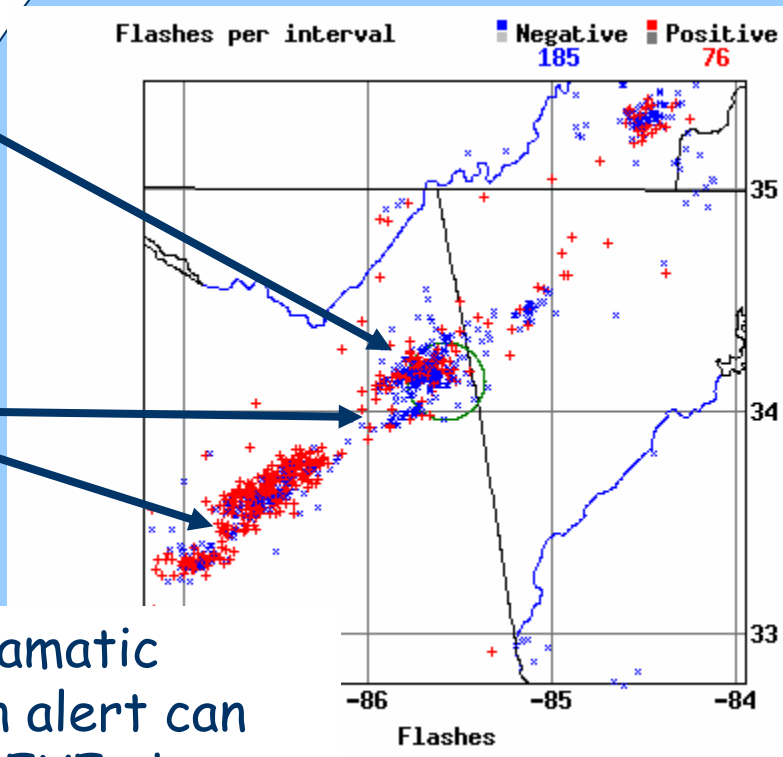
Execution of Multiple Plans on Multiple Platforms



Prototype Application of EVE Technology: Lightning Detection During Tornadic Activity

Tornado in Cherokee County Alabama on November 10, 2002

Large increase in both positive and negative lightning strikes during the tornado, as detected by sensors



When an EVE plan detects a dramatic increase in lightning activity, an alert can be sent to authorities, and the EVE plan can begin looking for tornadic activity

During this tornado, 88 homes were damaged or destroyed 4 injuries and 1 fatality

Uses of EVE for ESE's 23 Questions

How are the global precipitation, evaporation, and cycling of water changing?

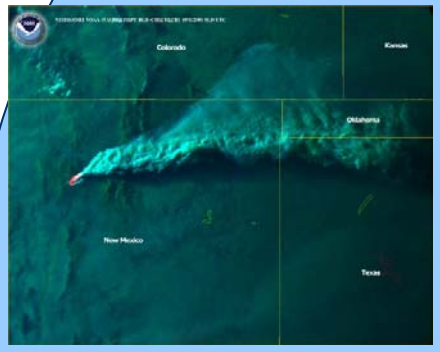
- **EVE can be used to recognize when and where high resolution sampling is required for pertinent atmospheric conditions, and to direct sensors accordingly**

What are the consequences of land cover and land use change for the sustainability of ecosystems and economic productivity?

- **EVE technologies could significantly improve the utility of NASA data for this type of regional monitoring, by allowing decision makers to tailor delivery of NASA data products based on their most immediate needs without taxing their data storage facilities with large and unnecessary volumes of data**

Future EVE Technology Infusion Examples: Event Detection

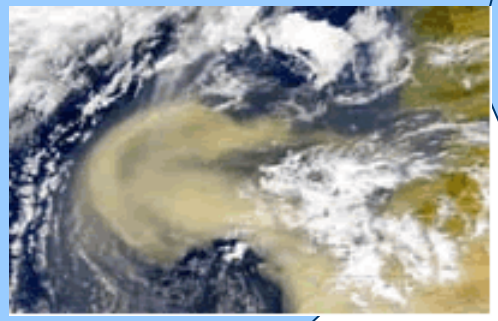
Plume Detection and Tracking



Landstat 7 of Forest Fires

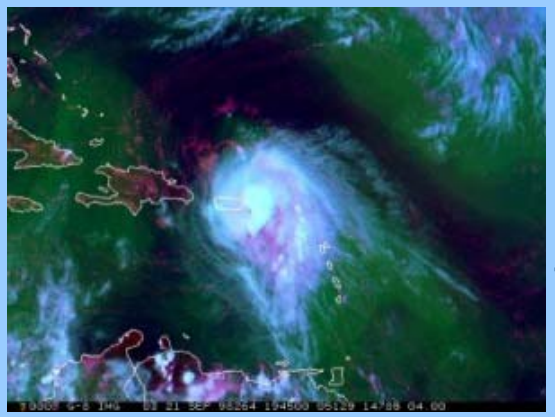
NOAA-14 data of Ruapehu eruption plume

Terra Satellite of 9/11

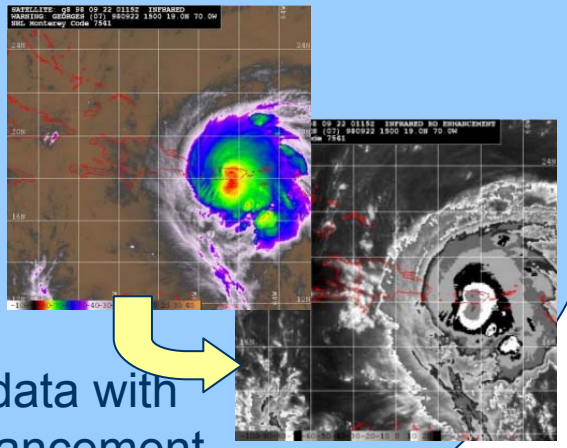


SeaWiFs of African Dust Storms

Using Sensor data from Hurricane Georges



Composite of 3 channels from AVHRR



GOES data with BD enhancement curve